Climate Change:
Science, Impacts, Technologies and Policy

A seminar series sponsored by
Georgia Tech's School of Public Policy and Climate and Energy Policy Laboratory

The Fifth Assessment Report of the IPCC: Transformation pathways: technologies for climate change mitigation

Marilyn Brown and Emanuele Massetti

Georgia Institute of Technology, April 8 2015

CLIMATE AND ENERGY POLICY LABORATORY
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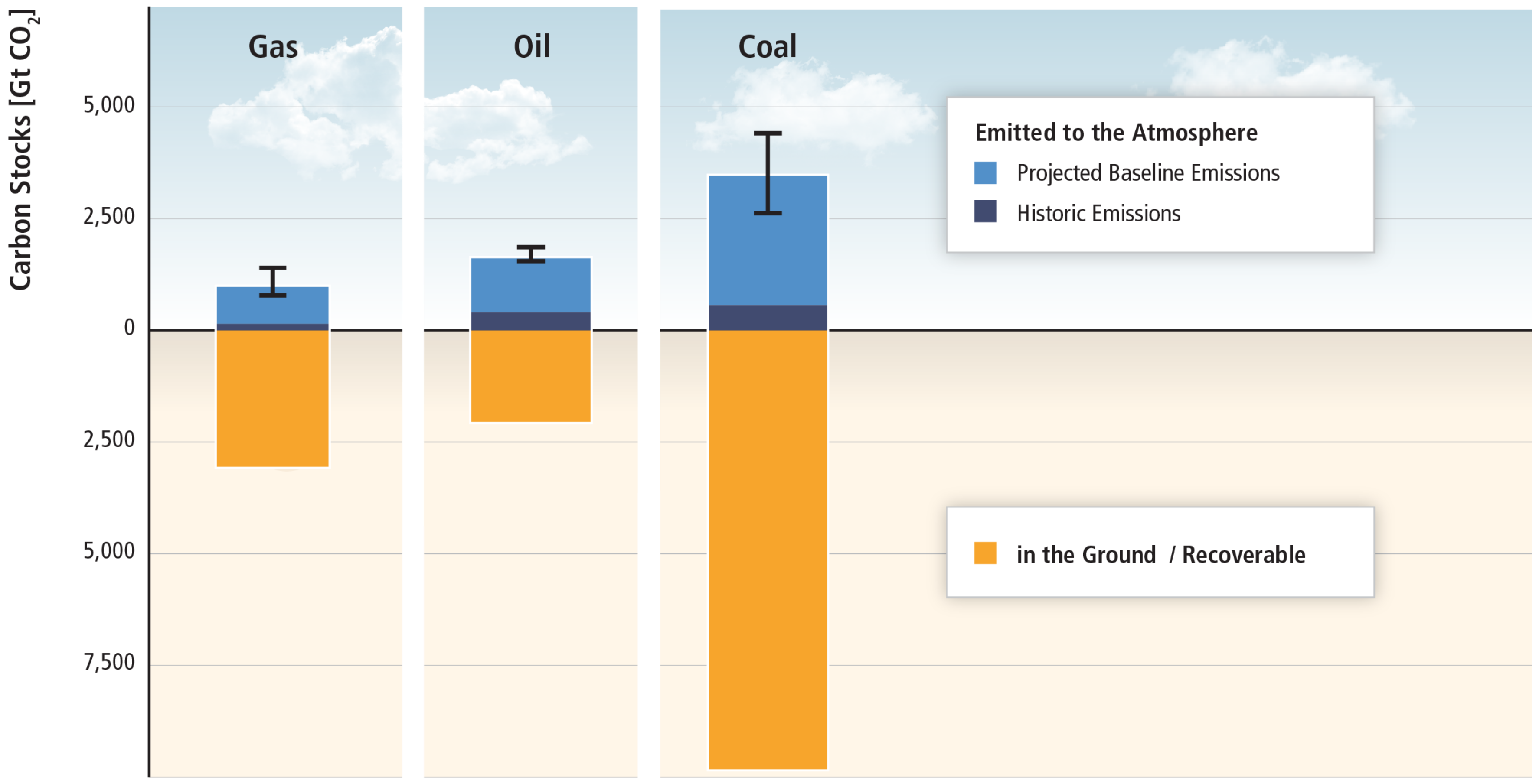
Climate change is a global commons problem.

There is far more carbon in the ground than emitted in any baseline scenario.



How hot would the planet get if we used all available fossil fuel?

“For those who don’t like suspense, here’s the total: an astonishing 16.2 degrees [F]. ”

(Michael Greenstone - New York Times – The Upshot – April 8 2015)

A nice rhetoric argument: forgets about extraction costs…

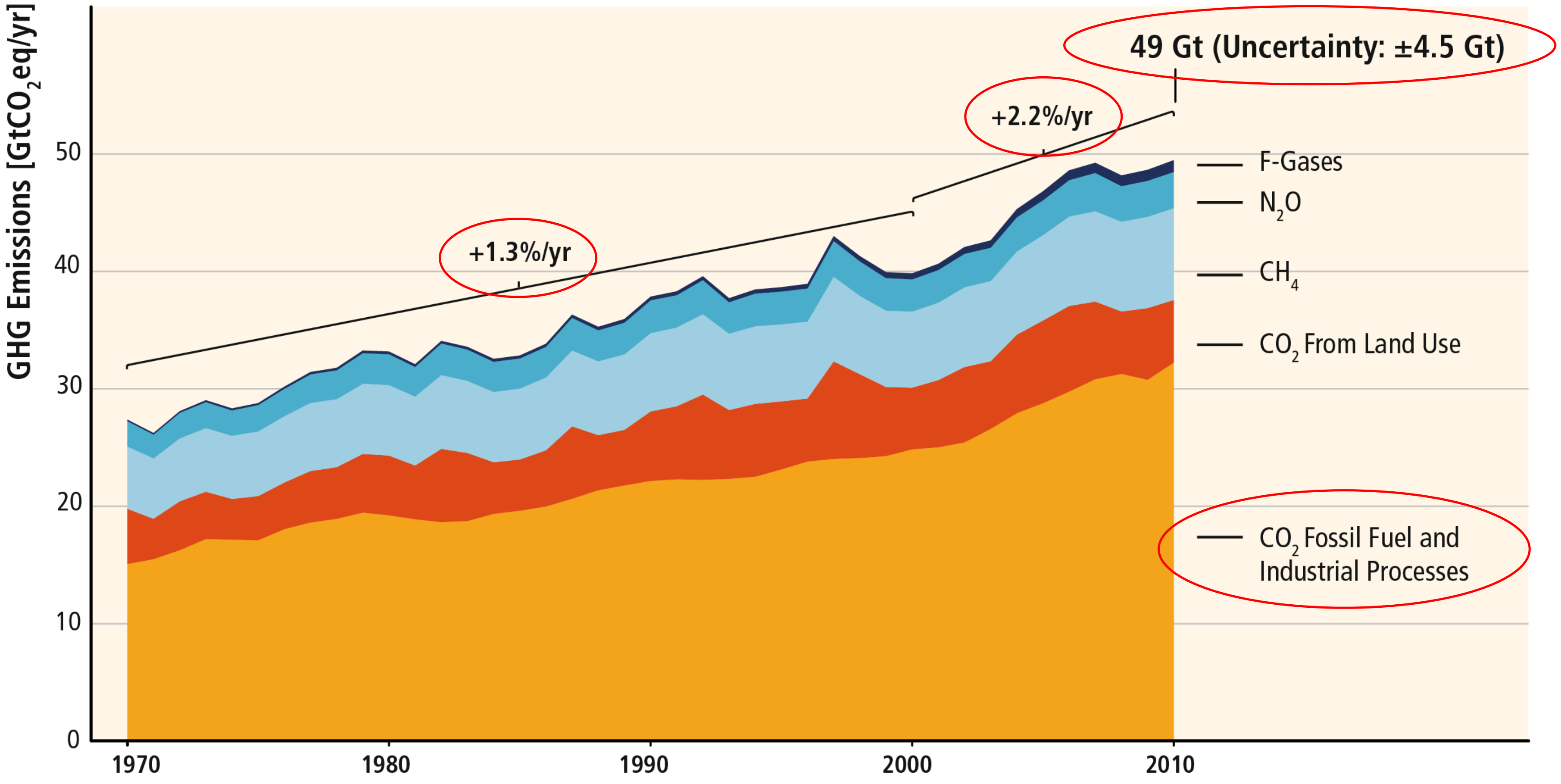
Where was this picture taken

The New York Times, April 8 2015

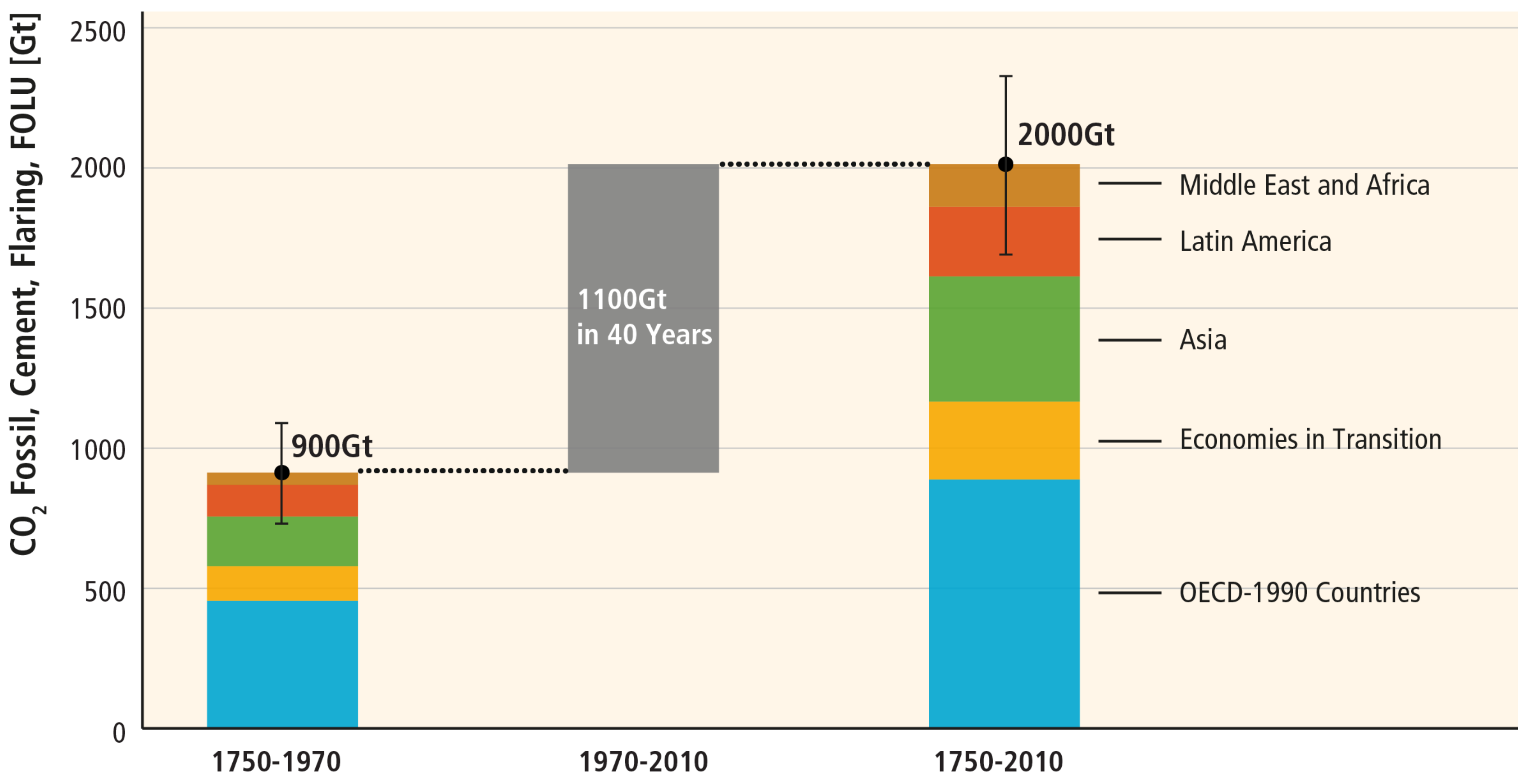
GHG emissions growth has accelerated ~~despite~~ reduction efforts.

due to very little

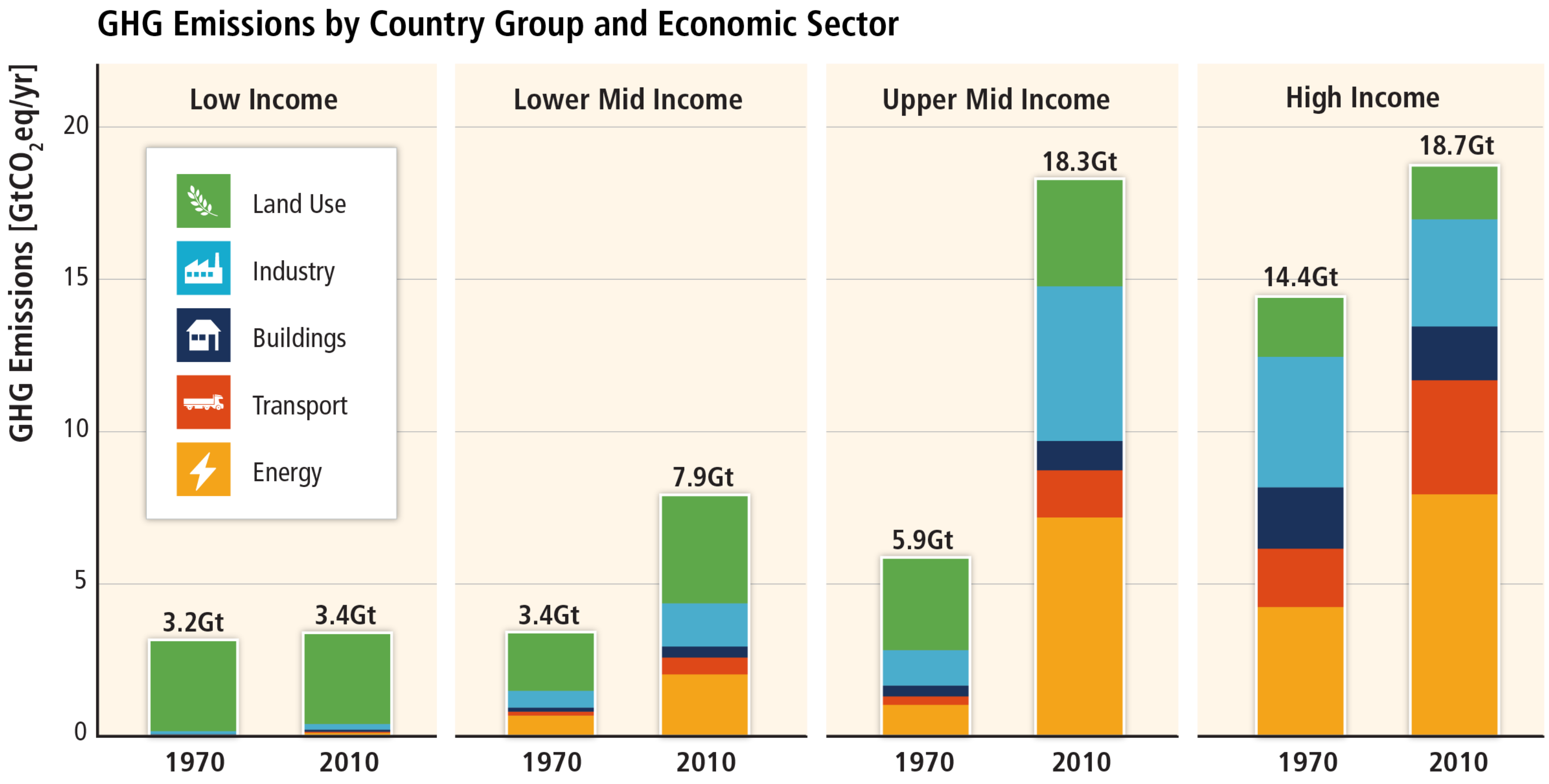
GHG emissions growth between 2000 and 2010 has been larger than in the previous three decades.



About half of cumulative anthropogenic CO_2 emissions between 1750 and 2010 have occurred in the last 40 years.



Regional patterns of GHG emissions are shifting along with changes in the world economy.

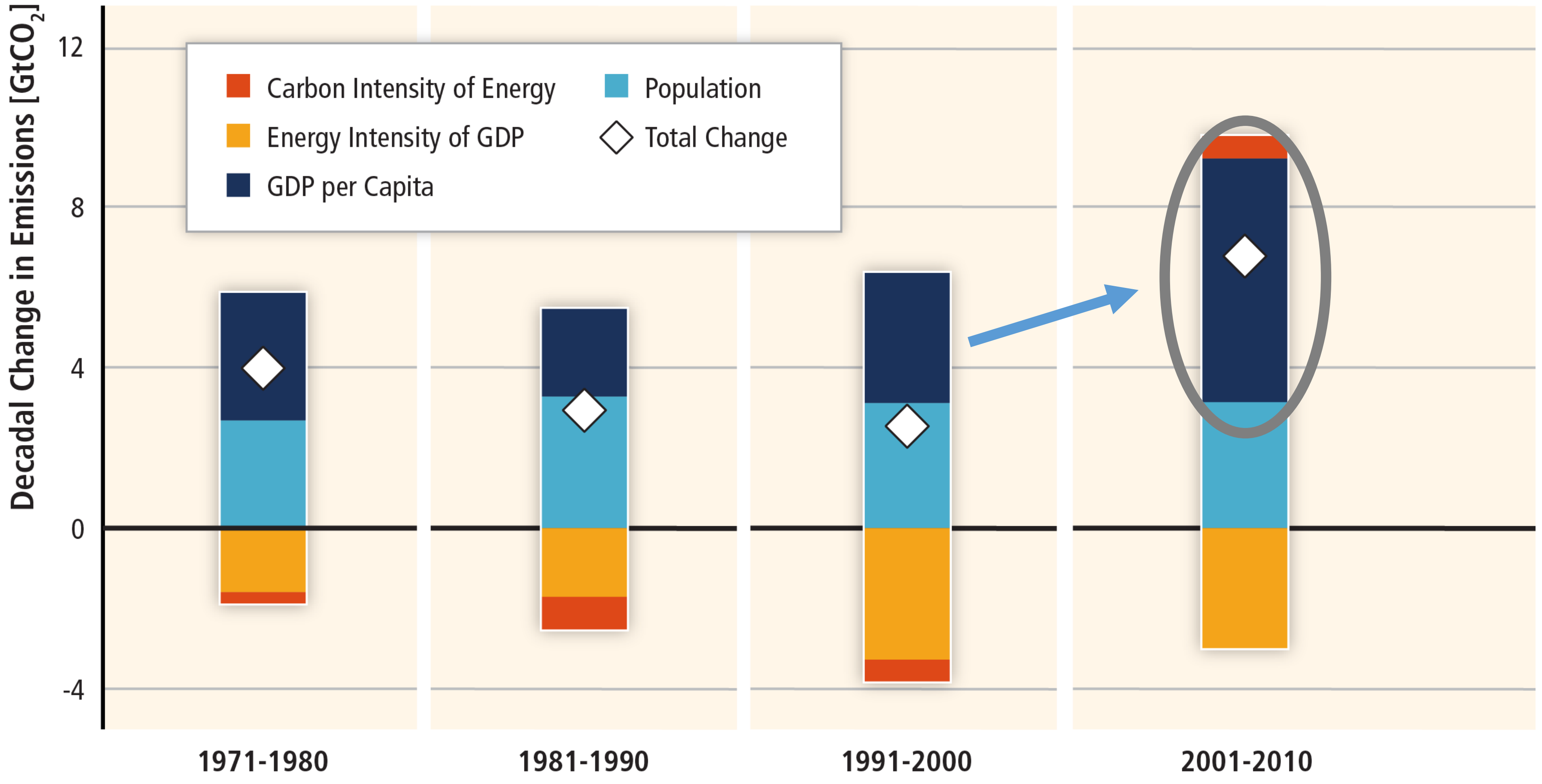


Main driver of emissions at the beginning of the century

Between 2003 and 2005 the power sector in China saw the fastest expansion ever recorded in world history:

- 66GWof new capacity were installed each year
- dominant role for coal-fired power plants
- more than one very large (1 GW) coal power plant per week

GHG emissions rise with growth in GDP and population; long-standing trend of decarbonisation of energy reversed.



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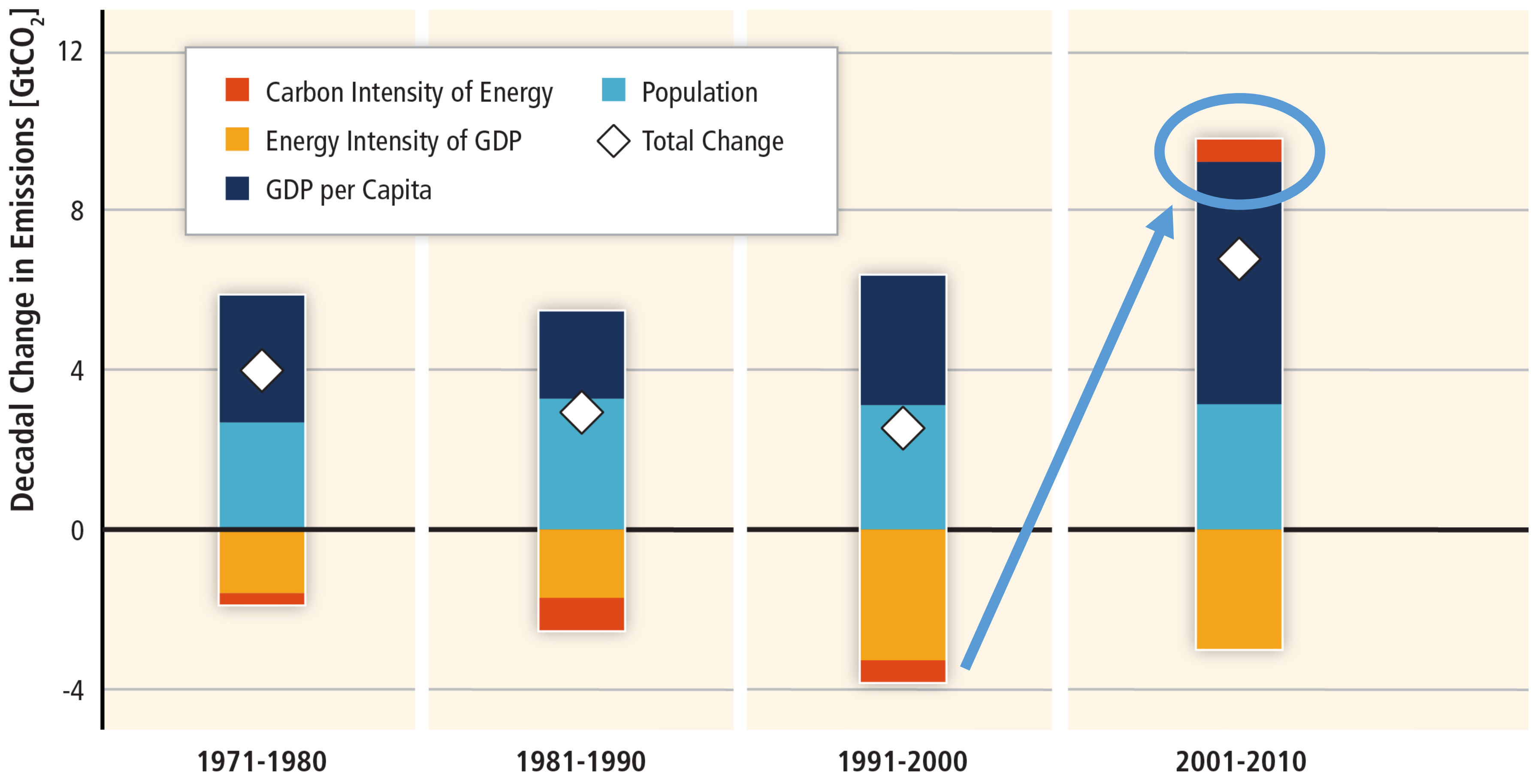
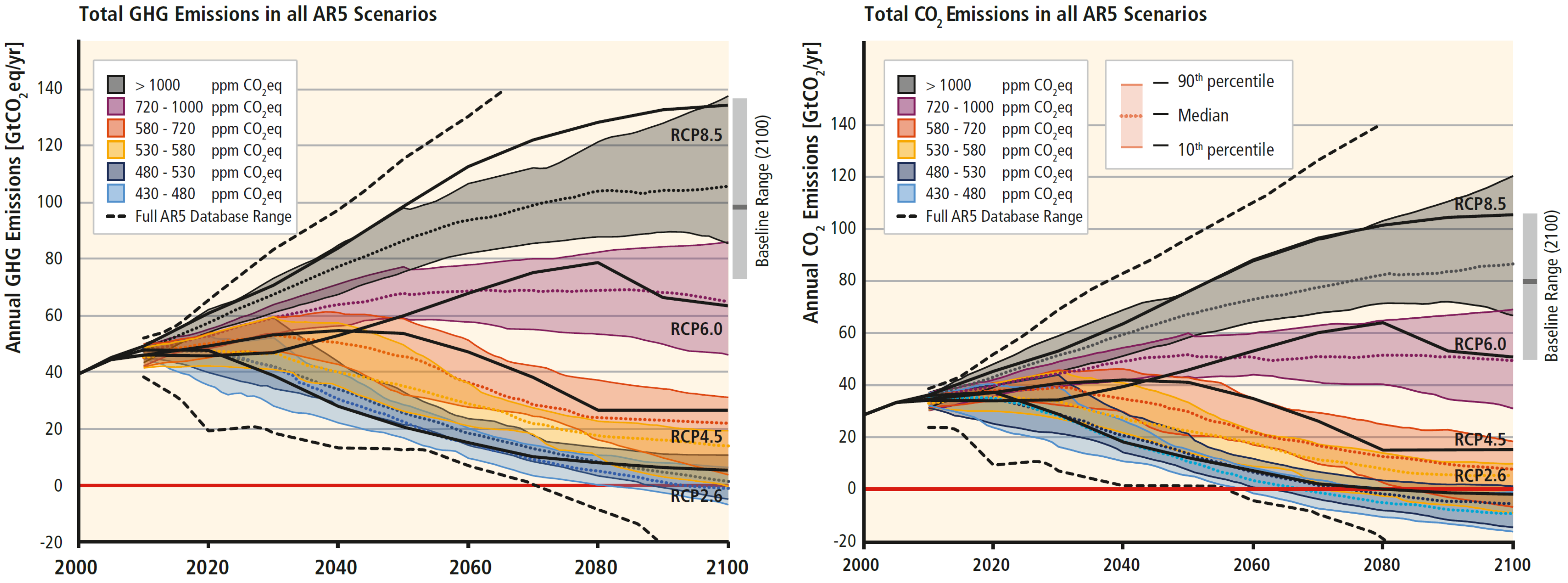
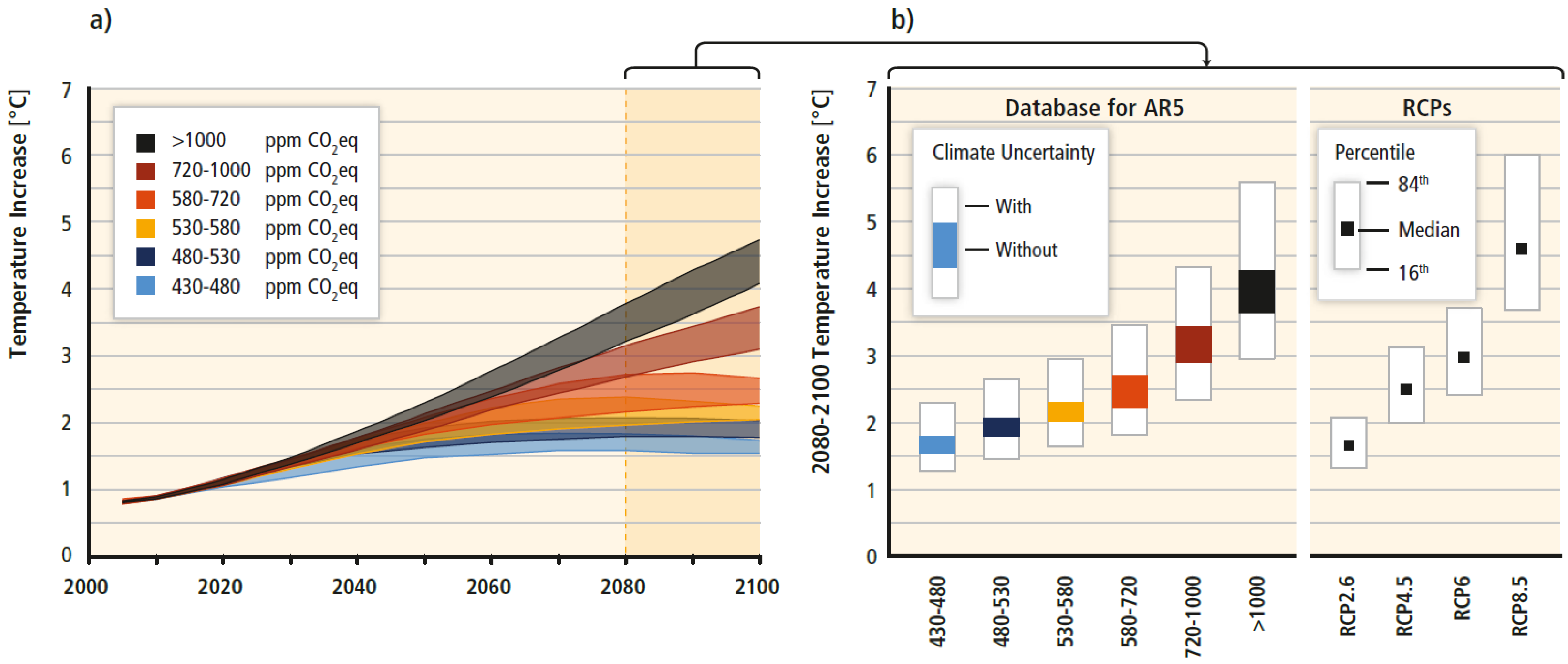


Limiting warming involves substantial technological, economic and institutional challenges.

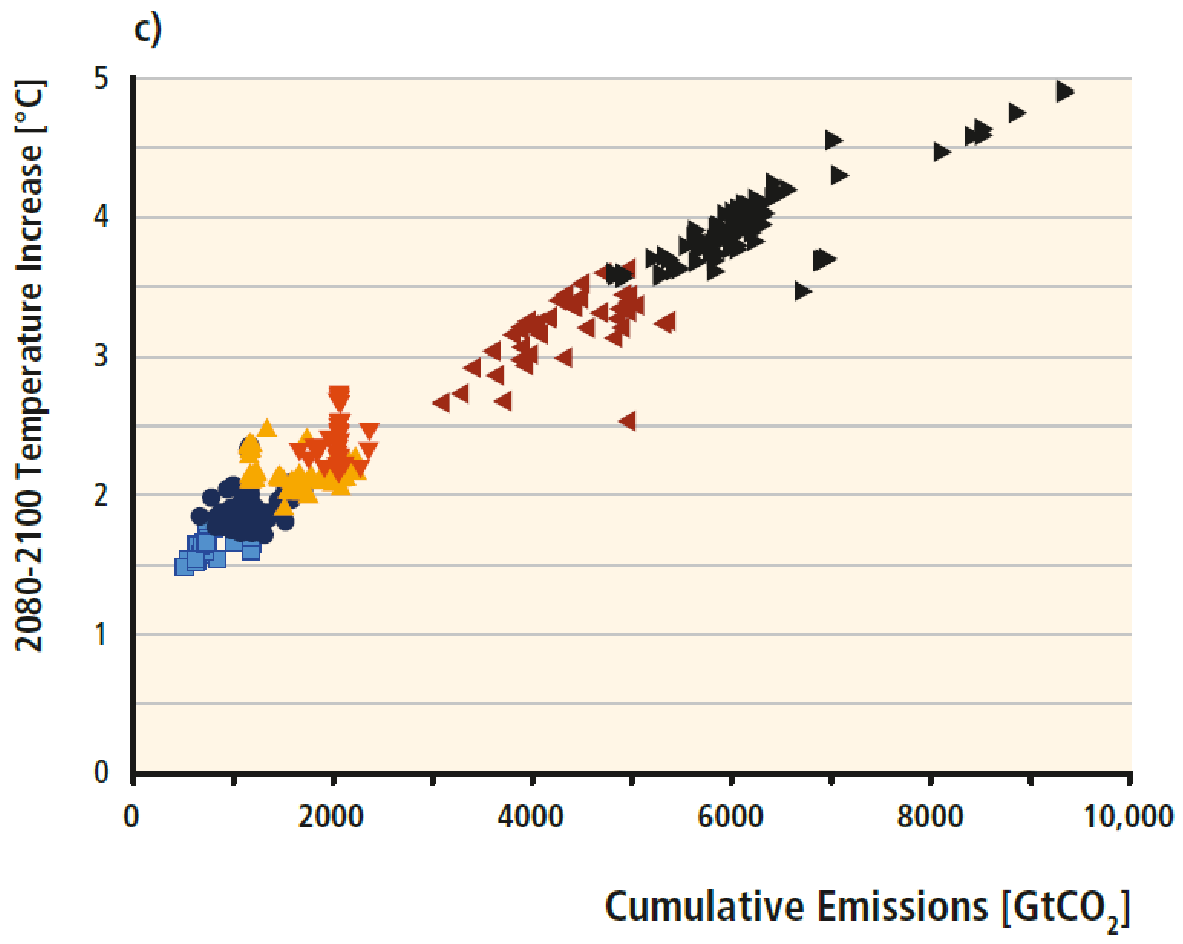
Emissions trajectories compared to Representative Concentration Pathways.



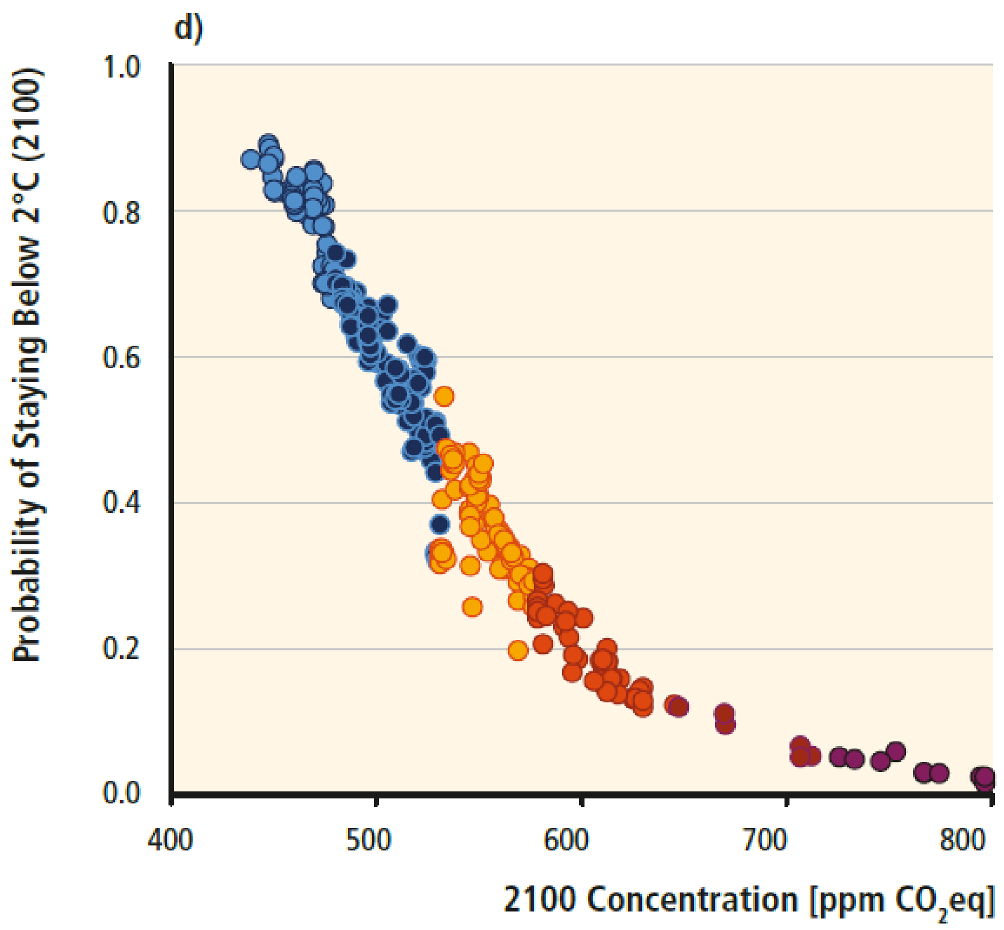
Temperature increase with respect to the pre-industrial level.



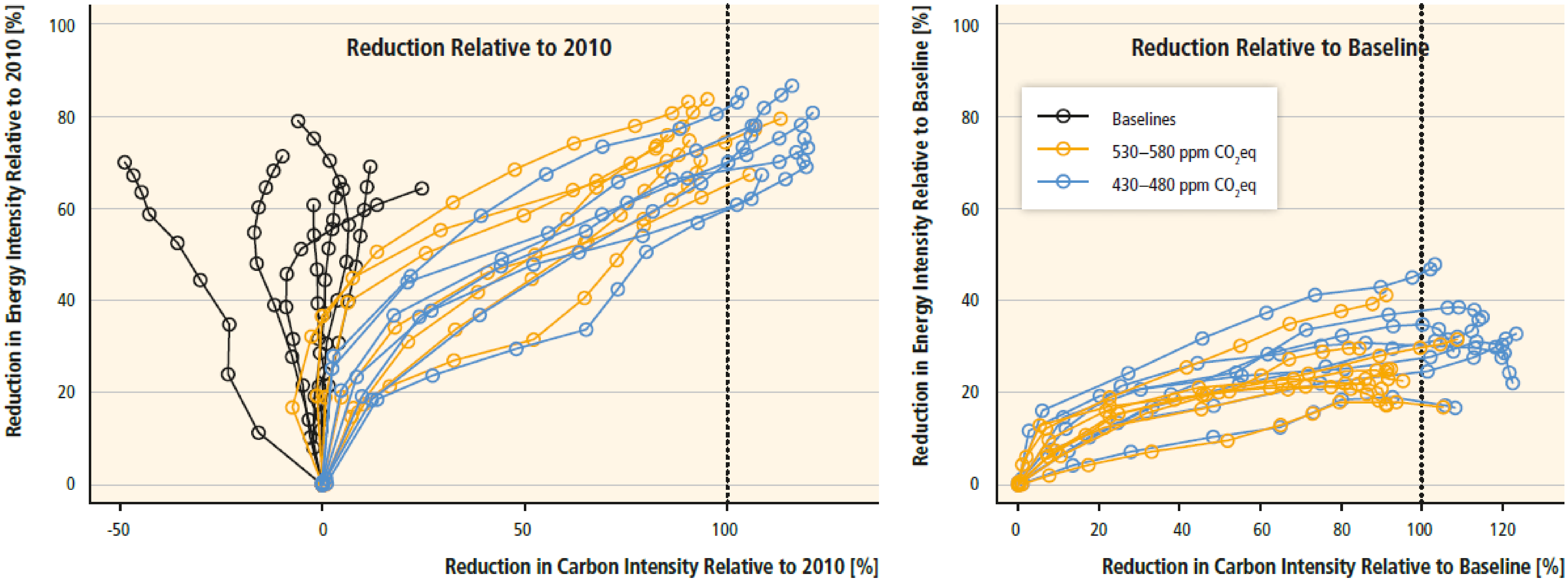
A linear relationship between cumulative emissions and temperature: carbon budgets.



Probability of keeping temperature increase below 2 degrees Celsius.



Carbon intensity vs energy intensity reductions.



Deep cuts in the use of fossil fuels.

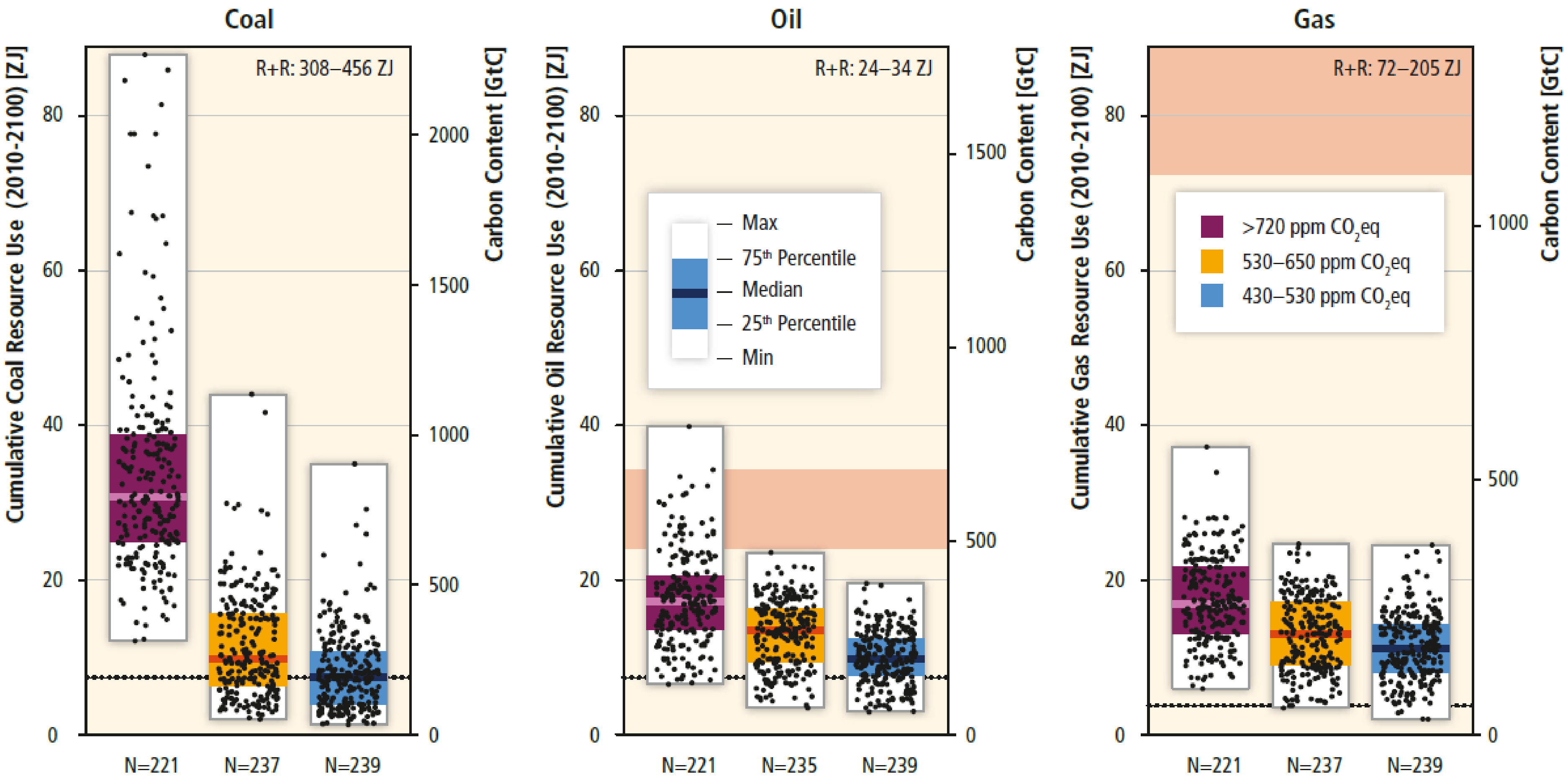
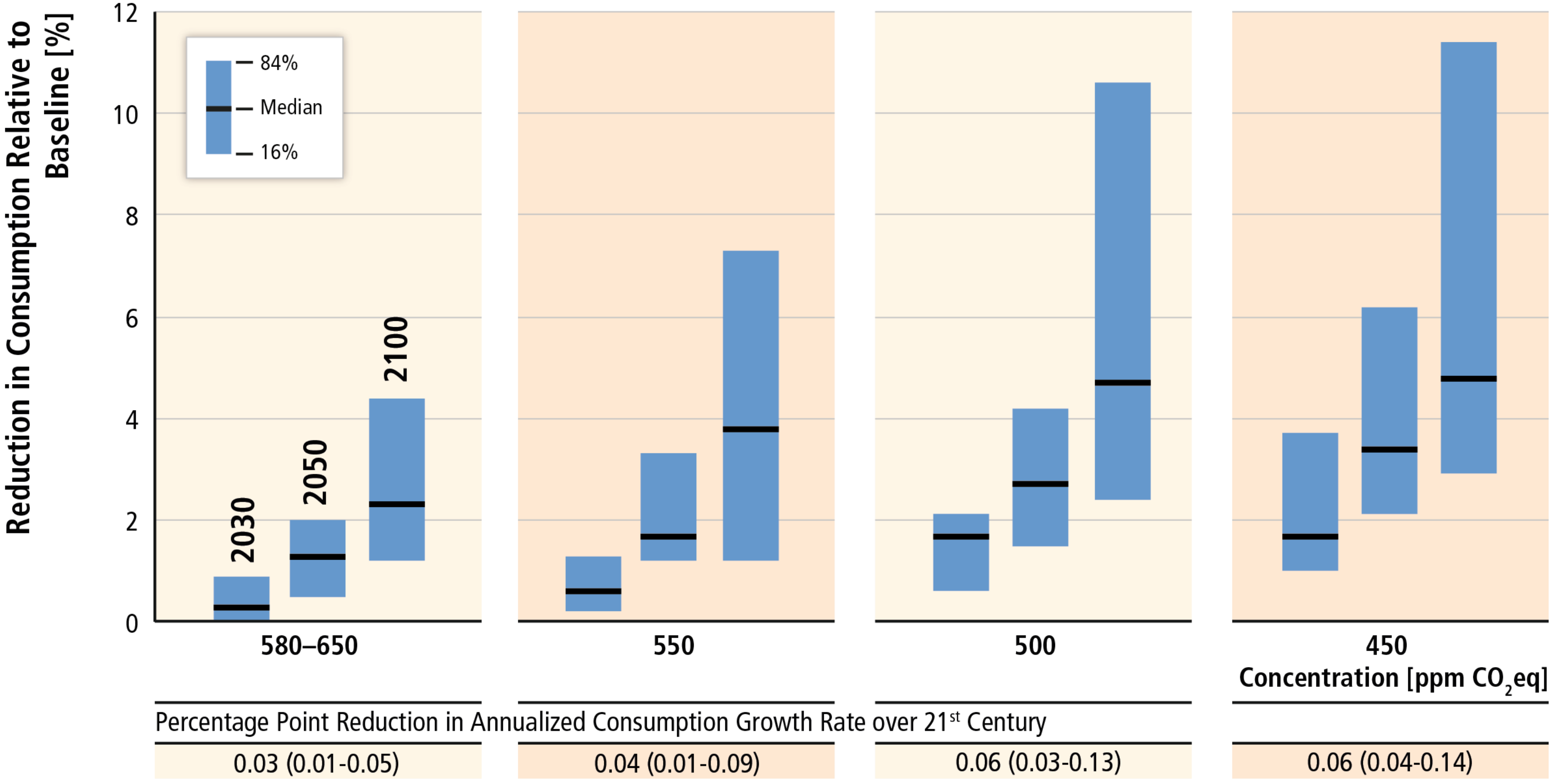


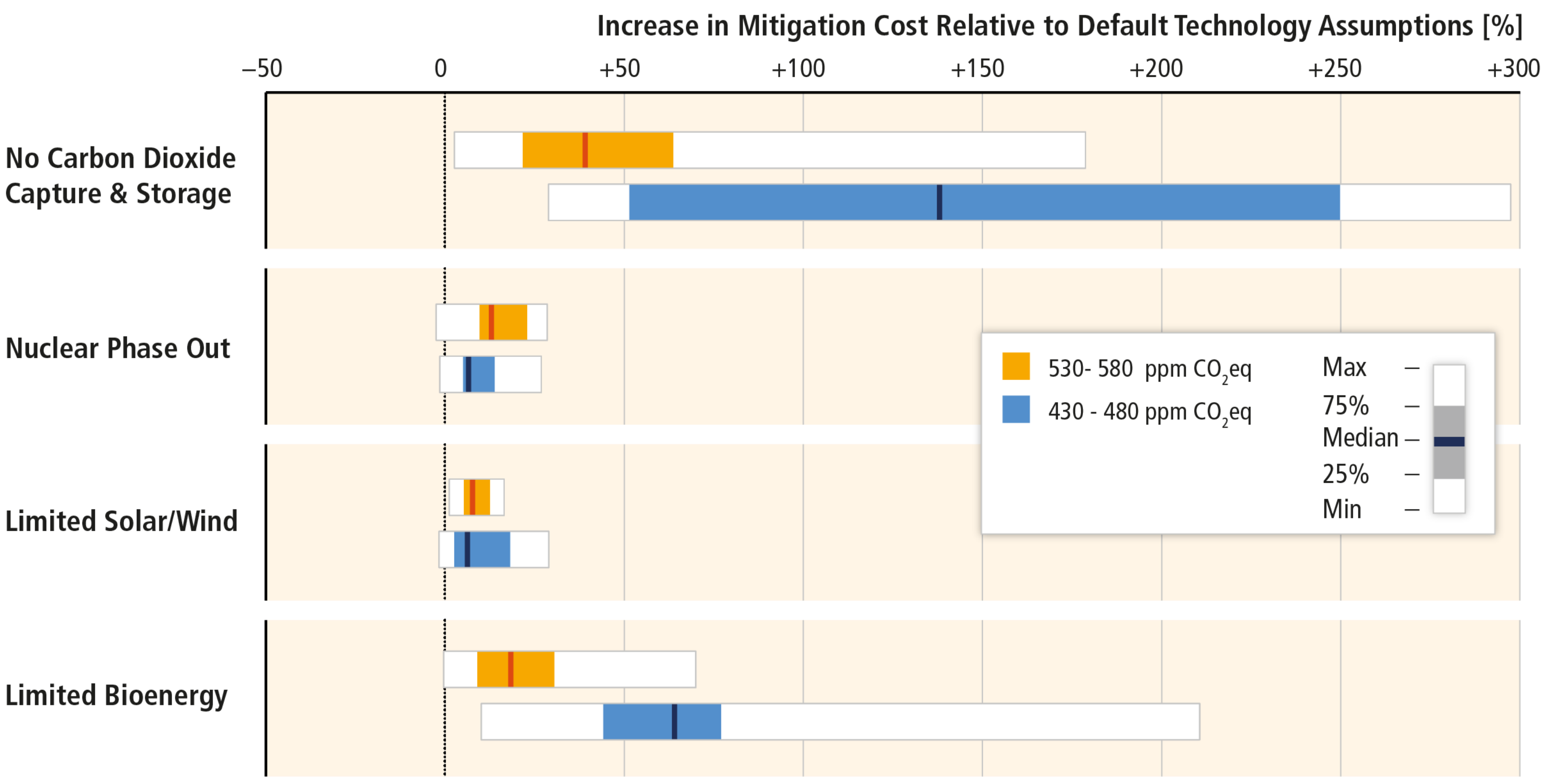
Figure 6.15 | Cumulative global coal, oil, and gas use between 2010 and 2100 in baseline and mitigation scenarios compared to reserves and resources. Estimates of reserves and resources ('R+R') are shown as shaded areas and historical cumulative use until 2010 is shown as dashed black line. Dots correspond to individual scenarios, of which the number in each sample is indicated at the bottom of each panel. Note that the horizontal distribution of dots does not have a meaning, but avoids overlapping dots. Source: WG III AR5 Scenario Database (Annex II.10). Includes only scenarios based on idealized policy implementation. Reserve, resource, and historical cumulative use from Table 7.1 in Section 7.4.1.

Global costs rise with the ambition of the mitigation goal.



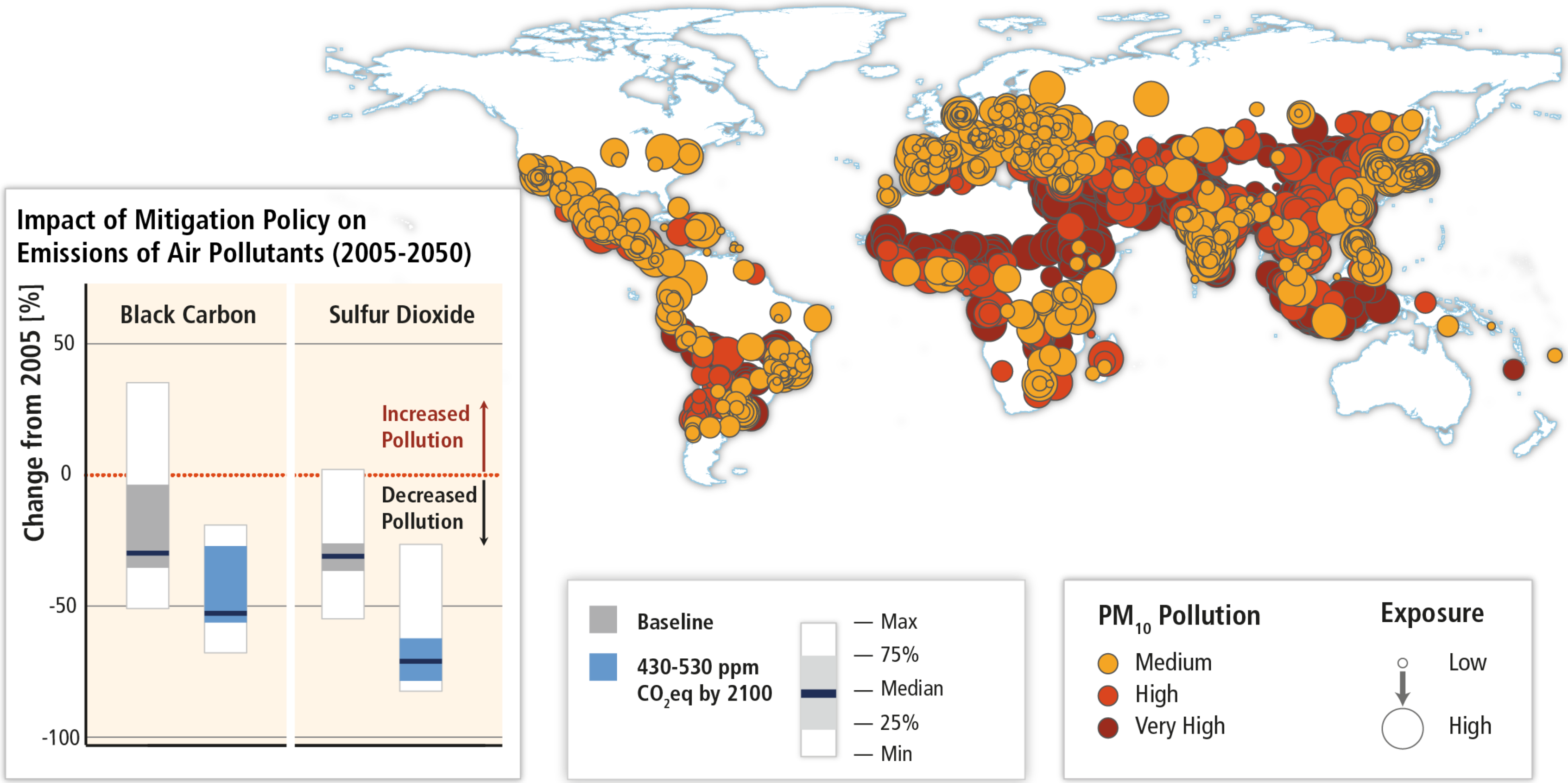
Based on Table SPM.2

Availability of technology can greatly influence mitigation costs.



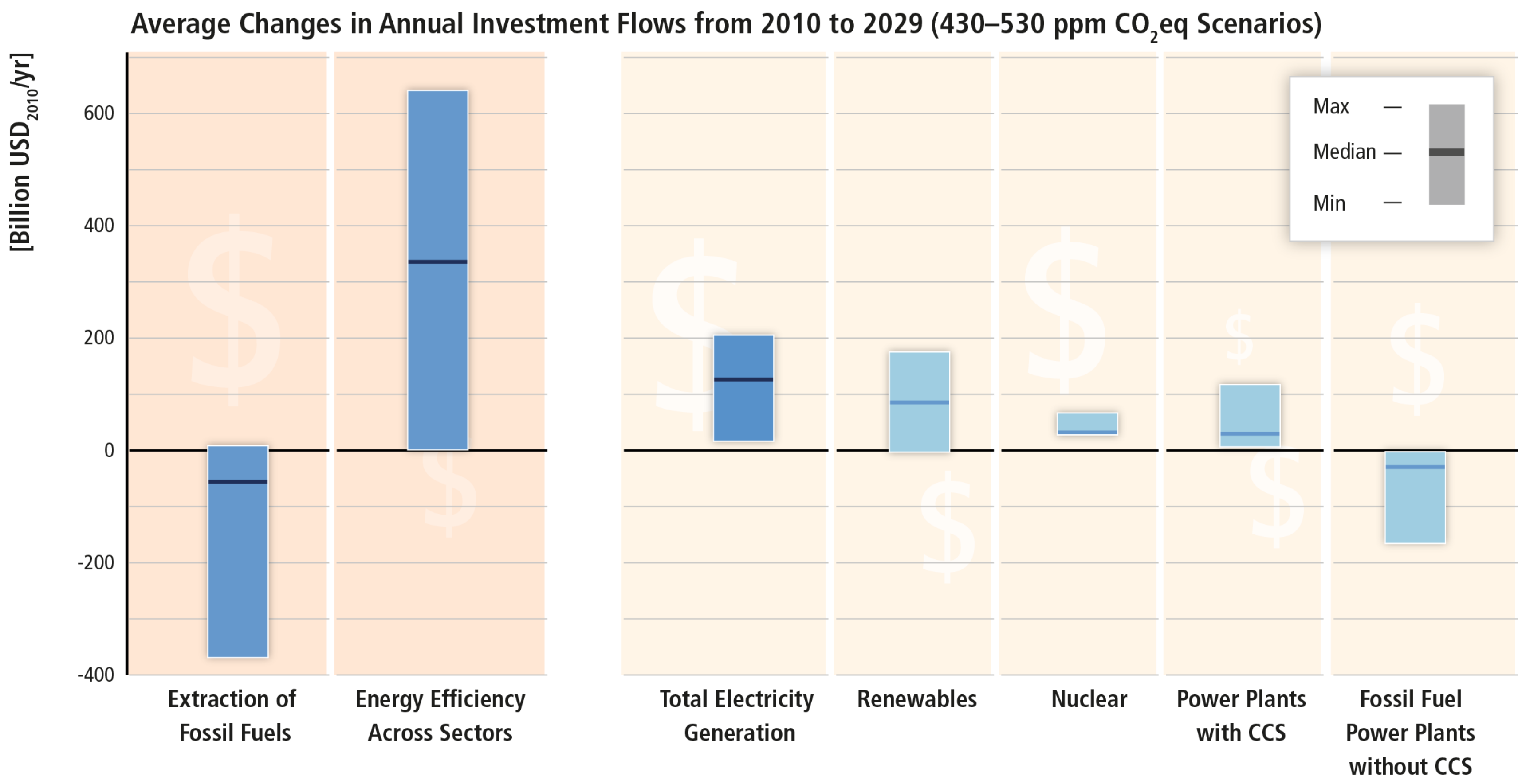
Based on Figure 6.24

Mitigation can result in large co-benefits for human health and other societal goals.



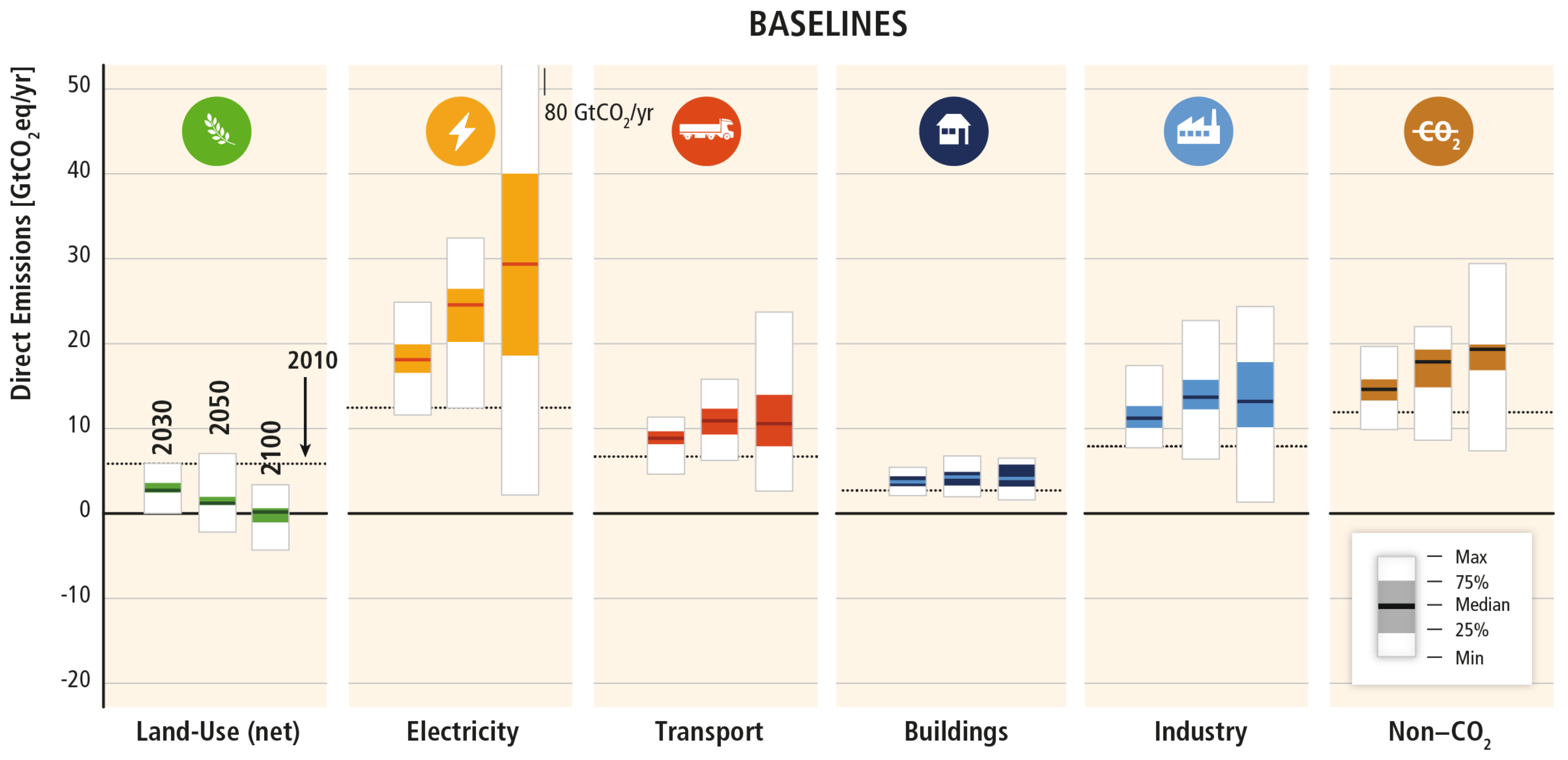
Based on Figures 6.33 and 12.23

Substantial reductions in emissions would require large changes in investment patterns

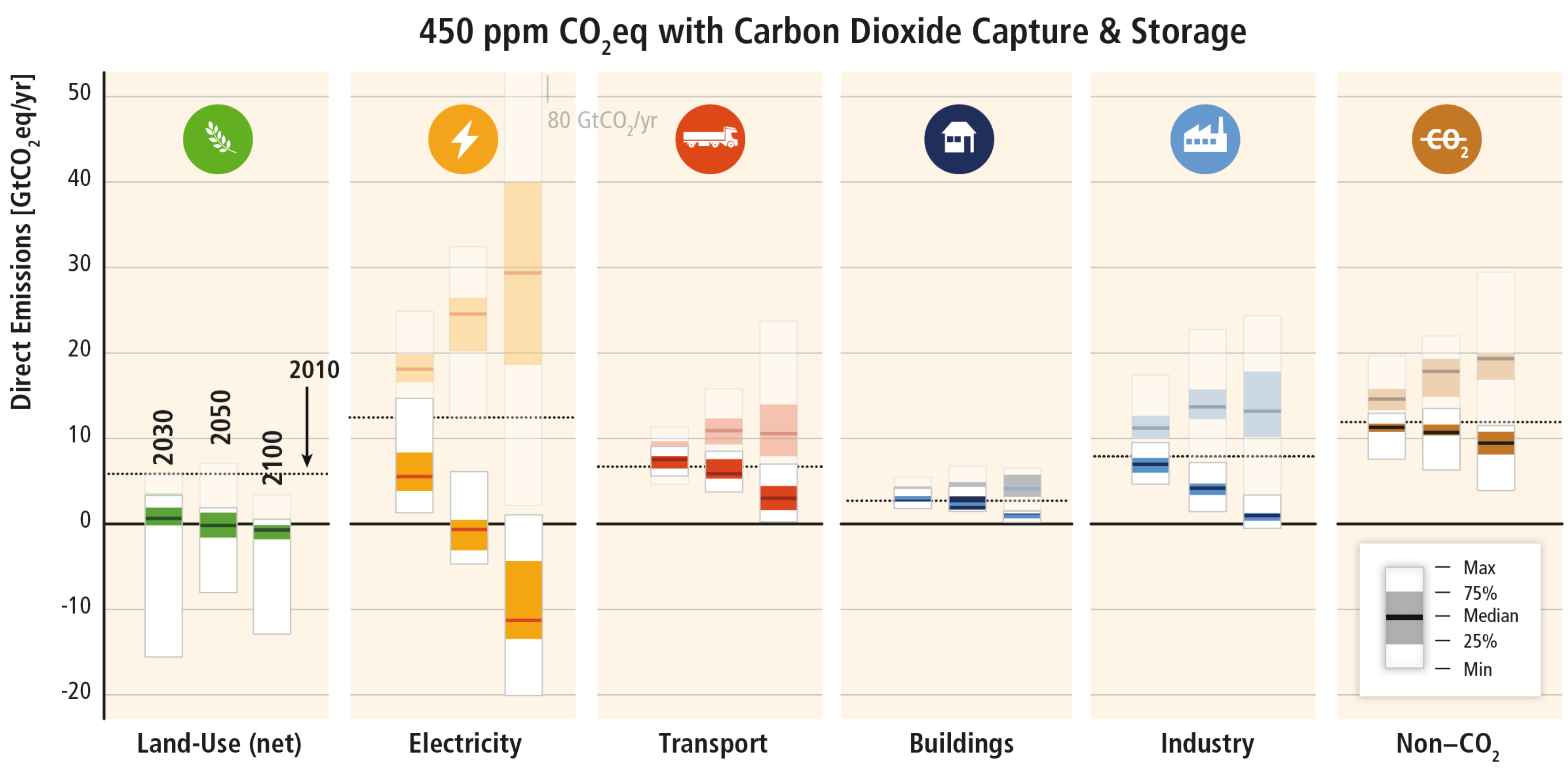


Transformation pathways by sector.

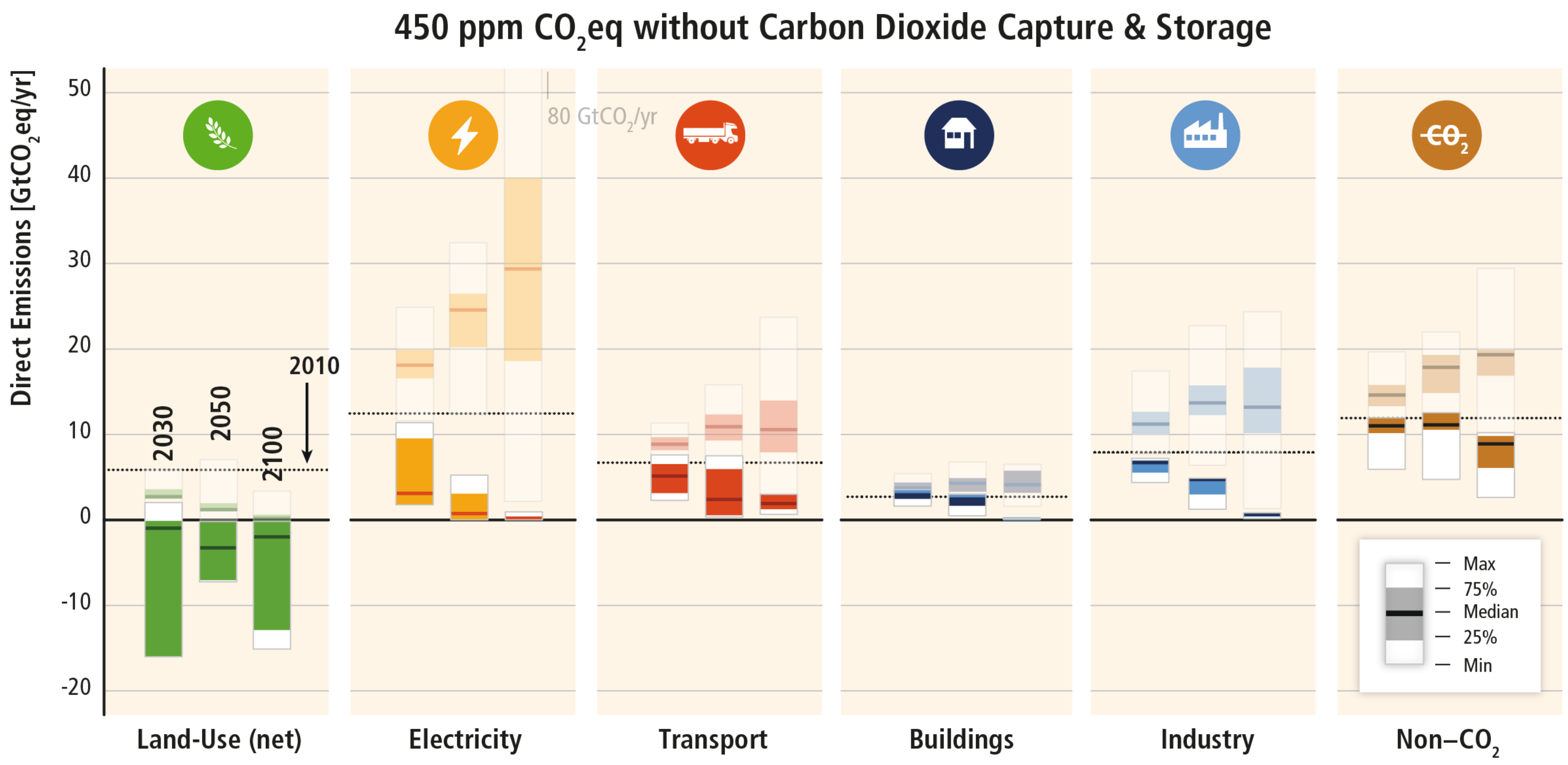
Baseline scenarios suggest rising GHG emissions in all sectors, except for CO_2 emissions in the land-use sector.



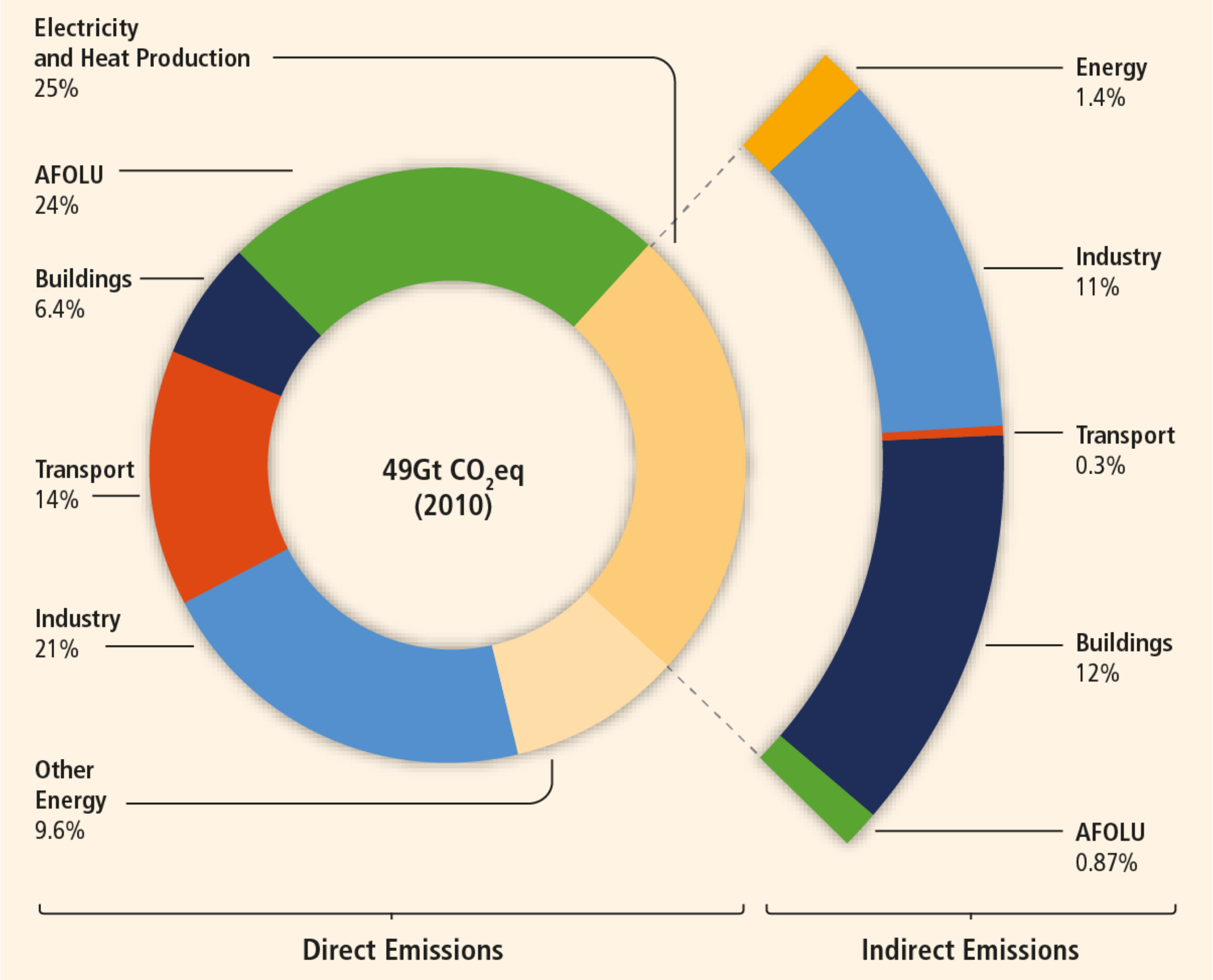
Mitigation requires changes throughout the economy. Systemic approaches are expected to be most effective.



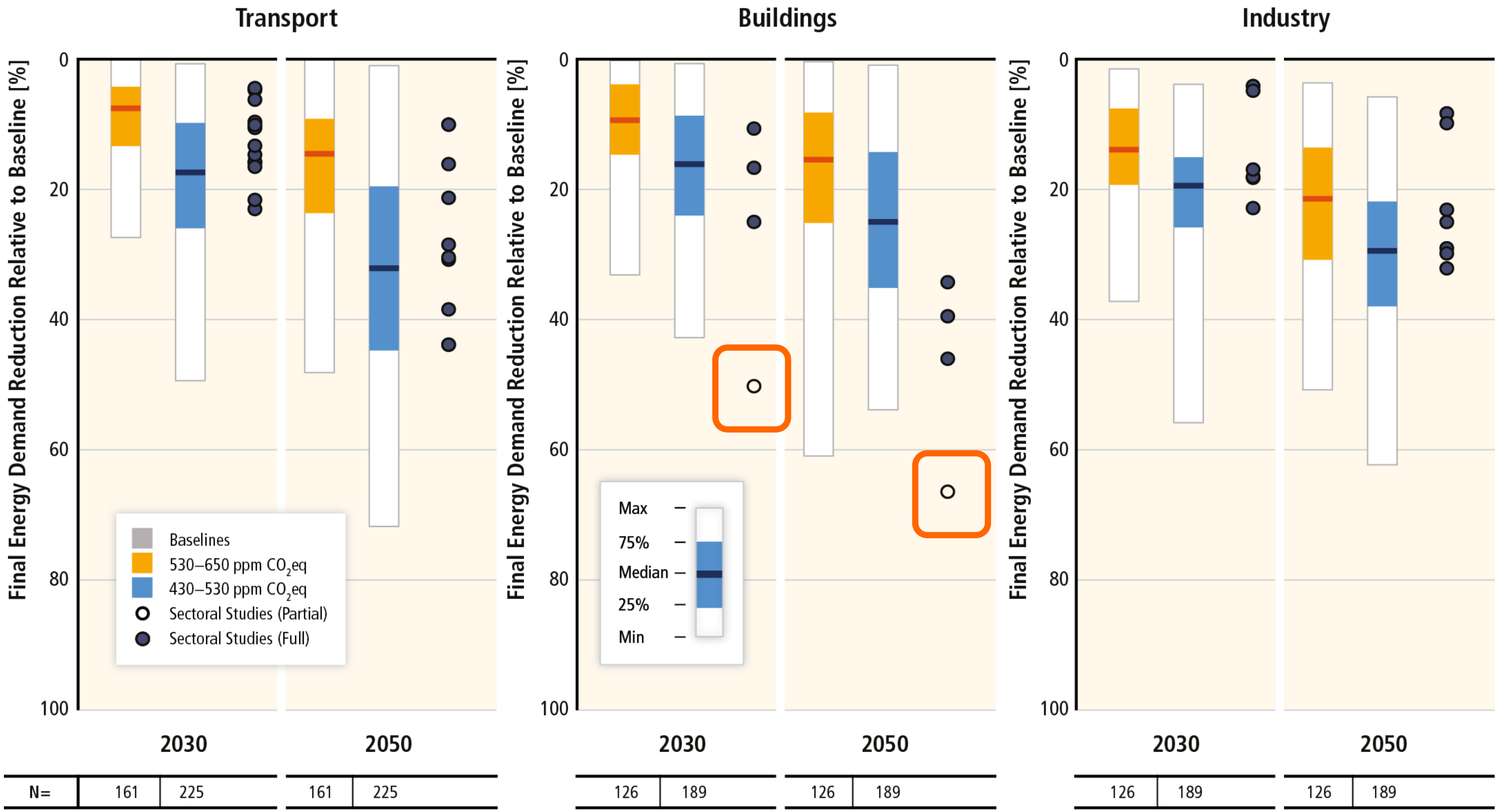
Mitigation efforts in one sector determine efforts in others.



If only direct emissions are reported, buildings are insignificant



Energy Demand Reduction Potential in Every Sector



The building sector is responsible for a high share of emissions

In 2010, the building sector accounted for:

- 32% of global final energy
- 25% of energy-related CO2 emissions
- 51% of global electricity consumption (70% for the US)
- a significant amount of F-gas emissions: up to a third of all such emissions

Per Capita Final Energy USe

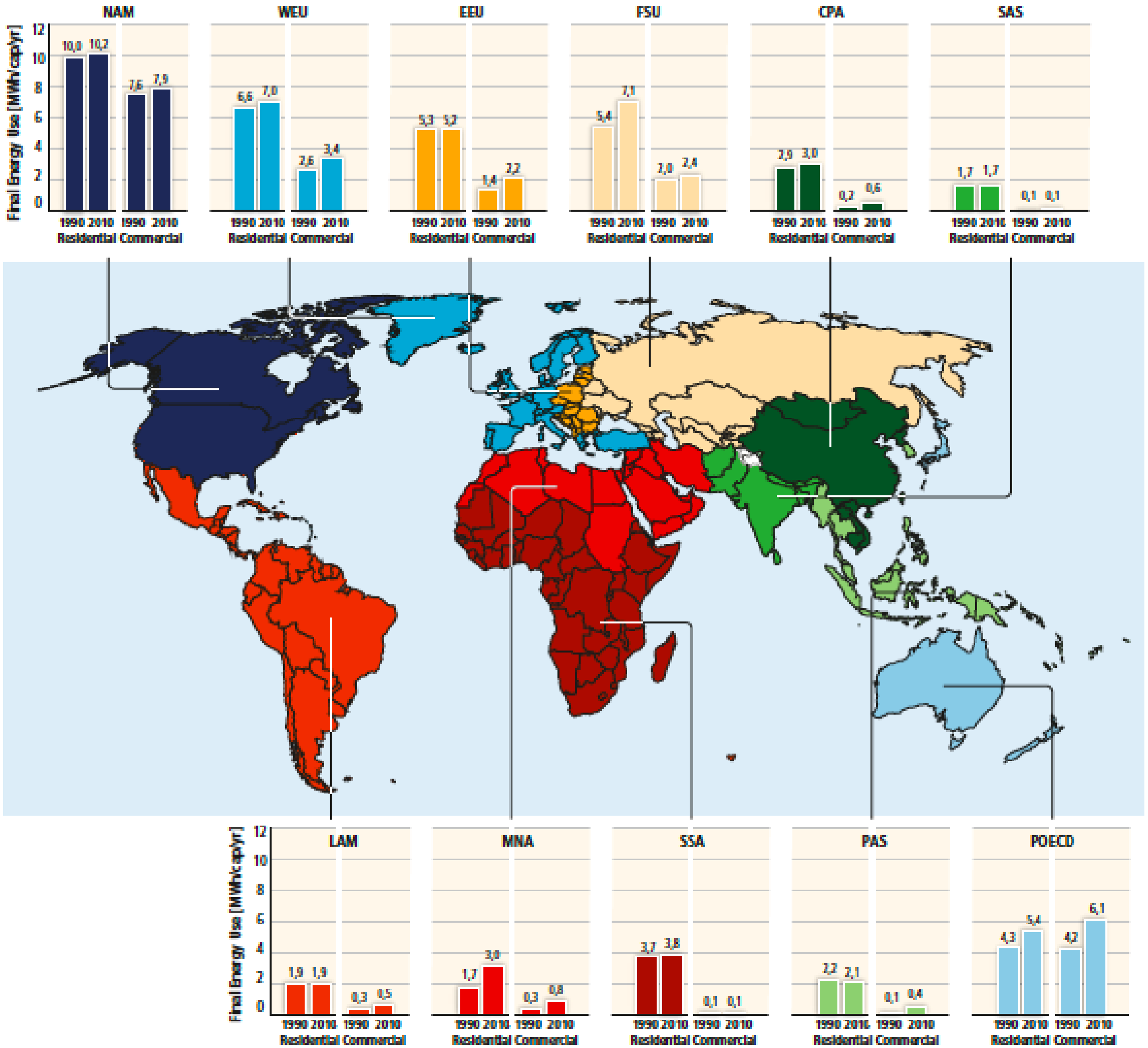


Figure SPM2 .

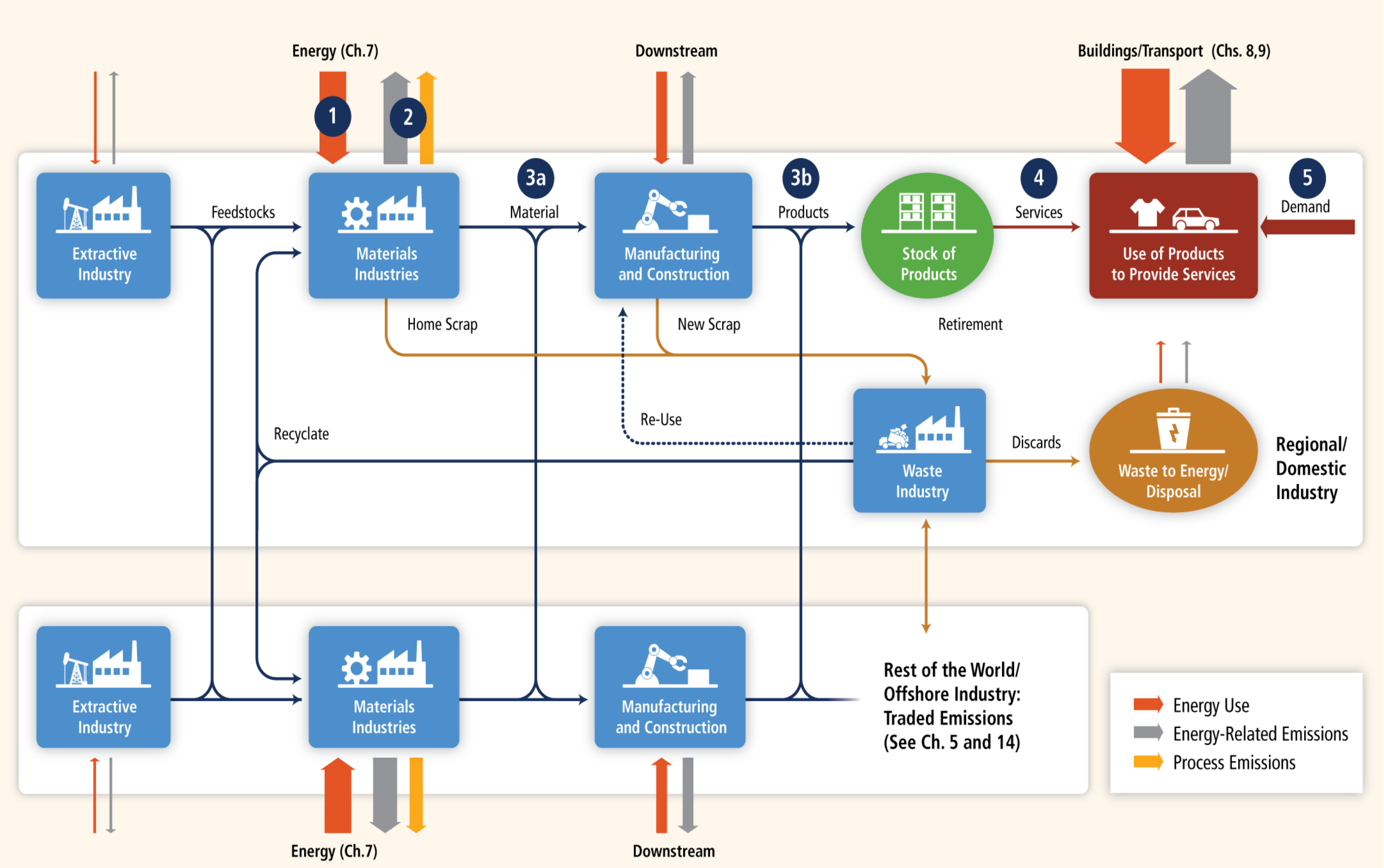
Figure 9.3 | Annual per capita final energy use of residential and commercial buildings for eleven regions (GEA RC11, see Annex II.2.4) in 1990 and 2010. Data from IEA (2012b, 2013).

Greenhouse Gas Emissions

Table 9.1 | Summary of chapter's main findings organized by major mitigation strategies (identities)

	Carbon efficiency	Energy efficiency of technology	System/(infrastructure) efficiency	Service demand reduction
Mitigation options	Building integrated RES (BiRES, BiPV). Fuel switching to low-carbon fuels such as electricity (9.4.1.2). Use of natural refrigerants to reduce halocarbon emissions (9.3.6). Advanced biomass stoves (9.3.8).	High-performance building envelope (HPE). Efficient appliances (EA). Efficient lighting (EL). Efficient Heating, Ventilation, and Air-Conditioning systems (eHVAC). Building automation and control systems (BACS). Daylighting, heat pumps, indirect evaporative cooling to replace chillers in dry climates, advances in digital building automation and control systems, smart meters and grids (9.3.2). Solar-powered desiccant dehumidification.	Passive House standard (PH). Nearly/net zero and energy plus energy buildings (NZEB) (9.3.3.3). Integrated Design Process (IDP). Urban planning (UP), (9.4.1). District heating/cooling (DH/C). Commissioning (C). Advanced building control systems (9.3.3.2). High efficiency distributed energy systems, co-generation, trigeneration, load levelling, diurnal thermal storage, advanced management (9.4.1.1). 'Smart-grids' (9.4.1.2). Utilization of waste heat (9.4.1.1)	Behavioural change (BC). Lifestyle change (LSC). Smart metering (9.4.1.2)

Five main options for reducing GHG emissions in the industry sector (considering also traded goods)



Industry (I)

- **GHG mitigation option categories comprises**

  (1) Energy efficiency (e.g., through furnace insulation, process coupling, or increased material recycling);

  (2) Emissions efficiency (e.g., from switching to non-fossil fuel electricity supply, or applying CCS to cement kilns);

  (3) Material efficiency

    (3a) Material efficiency in manufacturing (e.g., through reducing yield losses in blanking and stamping sheet metal or re-using old structural steel without melting);

    (3b) Material efficiency in product design (e.g., through extended product life, light-weight design, or de-materialization);

  (4) Product-Service efficiency (e.g., through car sharing, or higher building occupancy);

  (5) Service demand reduction (e.g., switching from private to public transport, new product design with longer life)

Industry (II)

- From a short and mid-term perspective energy efficiency and behaviour change could significantly contribute to GHG mitigation

- In the long-term a shift to low-carbon electricity, radical product innovations (e.g. alternatives to cement), or CCS could contribute to significant GHG emissions reductions

- Systemic approaches and collaborative activities across companies and sectors and especially SMEs through clusters can reduce energy and material consumption and thus GHG emissions

- Important options for mitigation in waste management is waste reduction, followed by re-use, recycling and energy recovery

The 4-Legged Stool for Reducing GHG Emissions

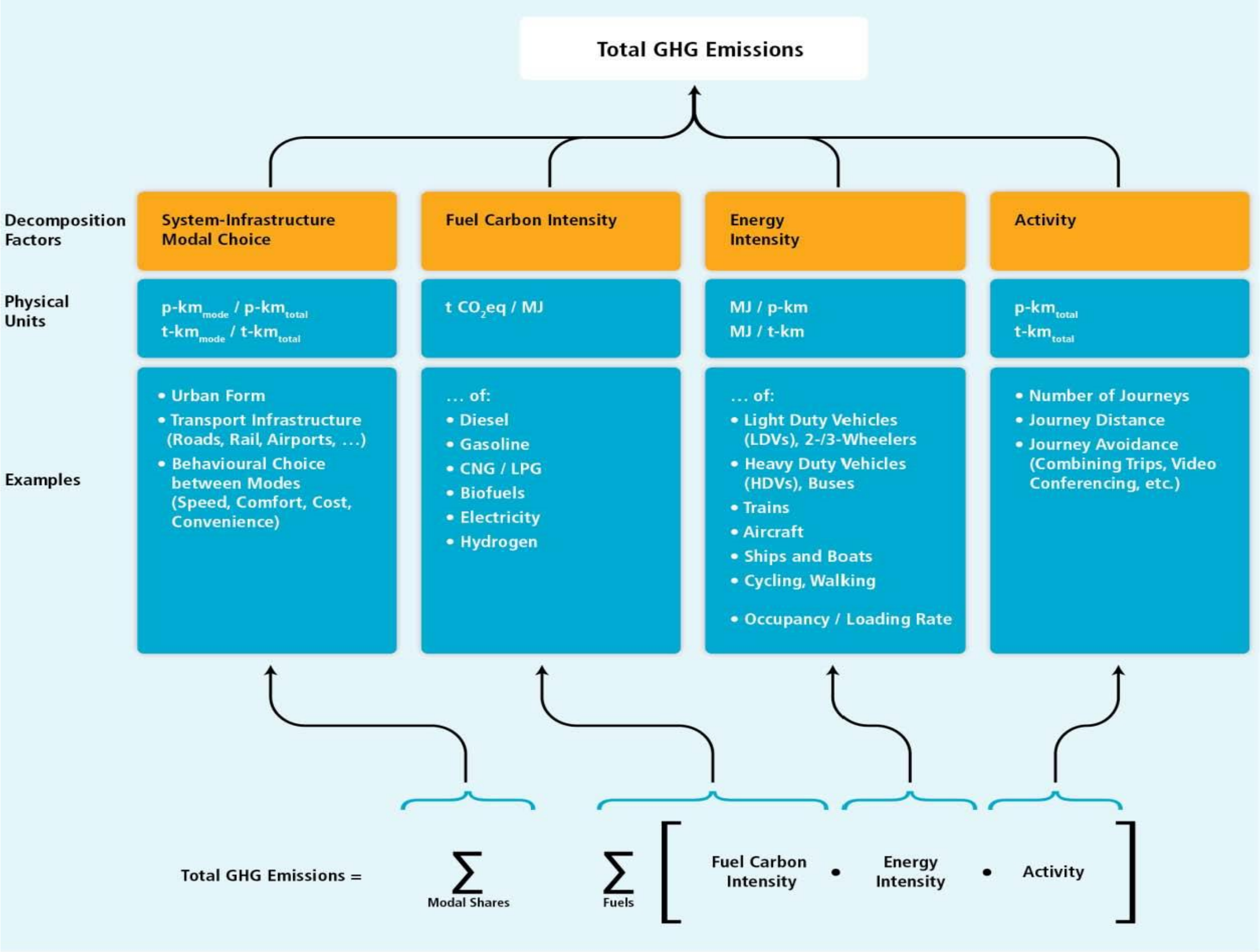
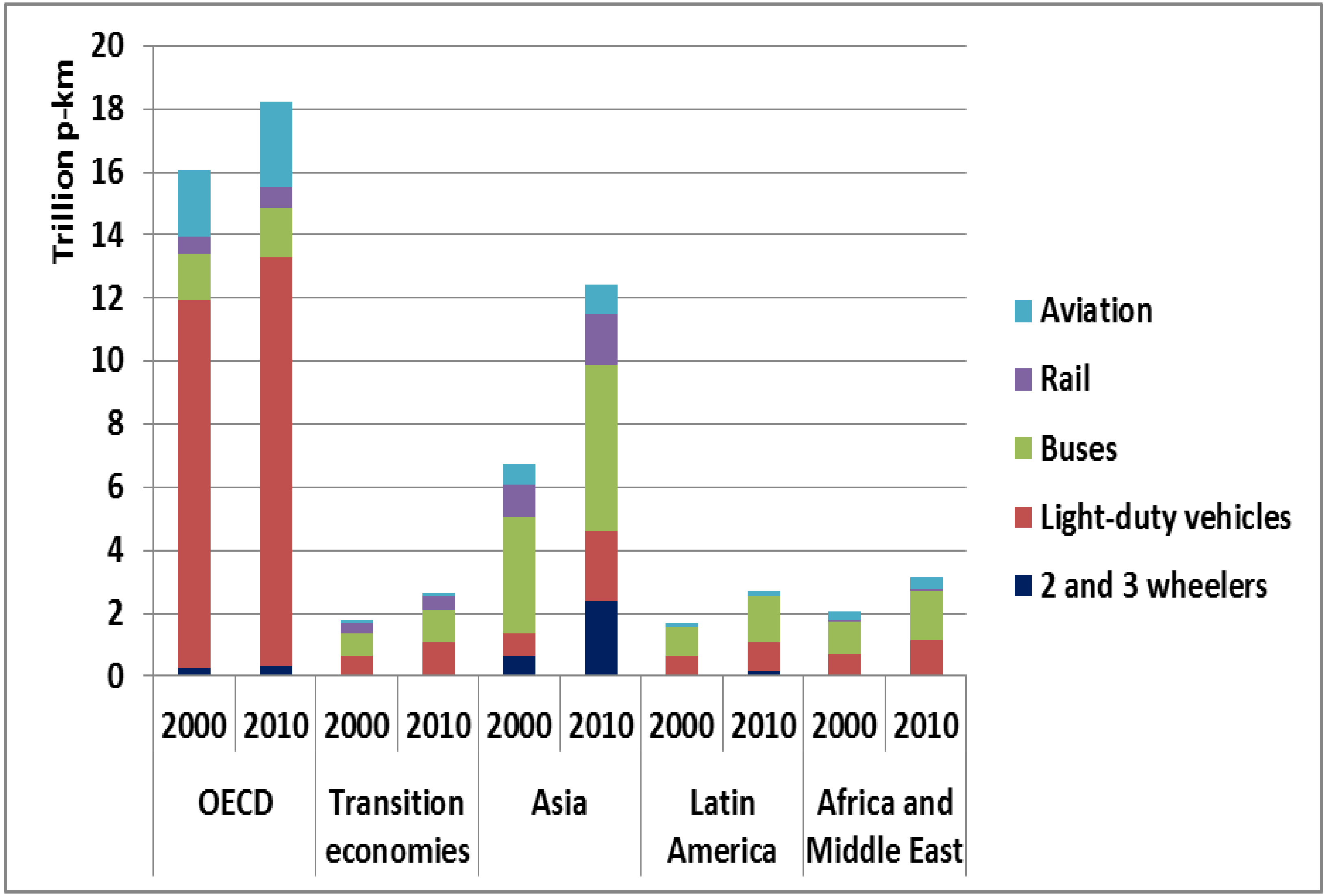


Figure 8.2 from IPCC Mitigation report

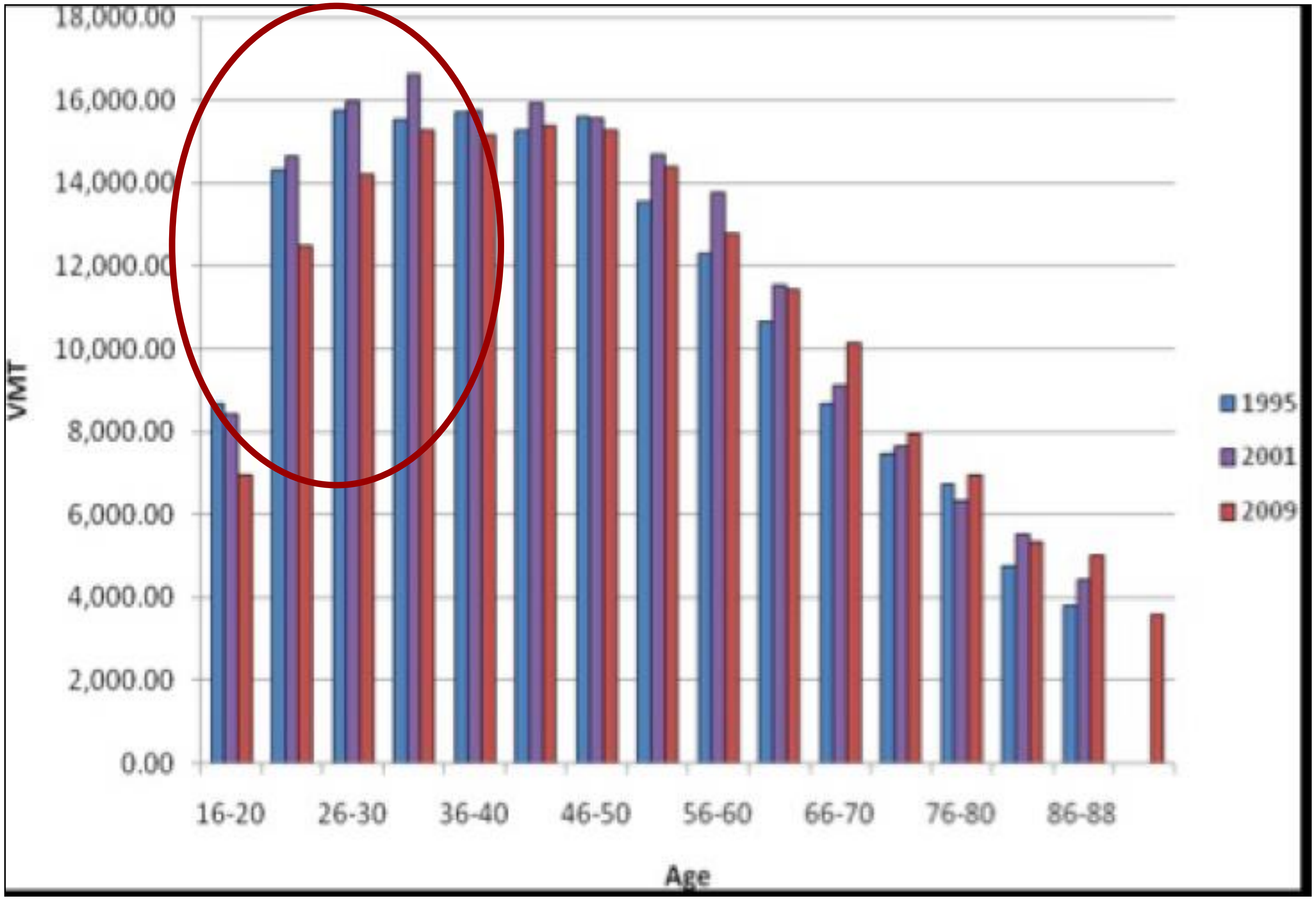
P km = passenger-km; t-km = tonne-km;

CNG = compressed natural gas; LPG = liquid petroleum gas

Major regional differences have been highlighted



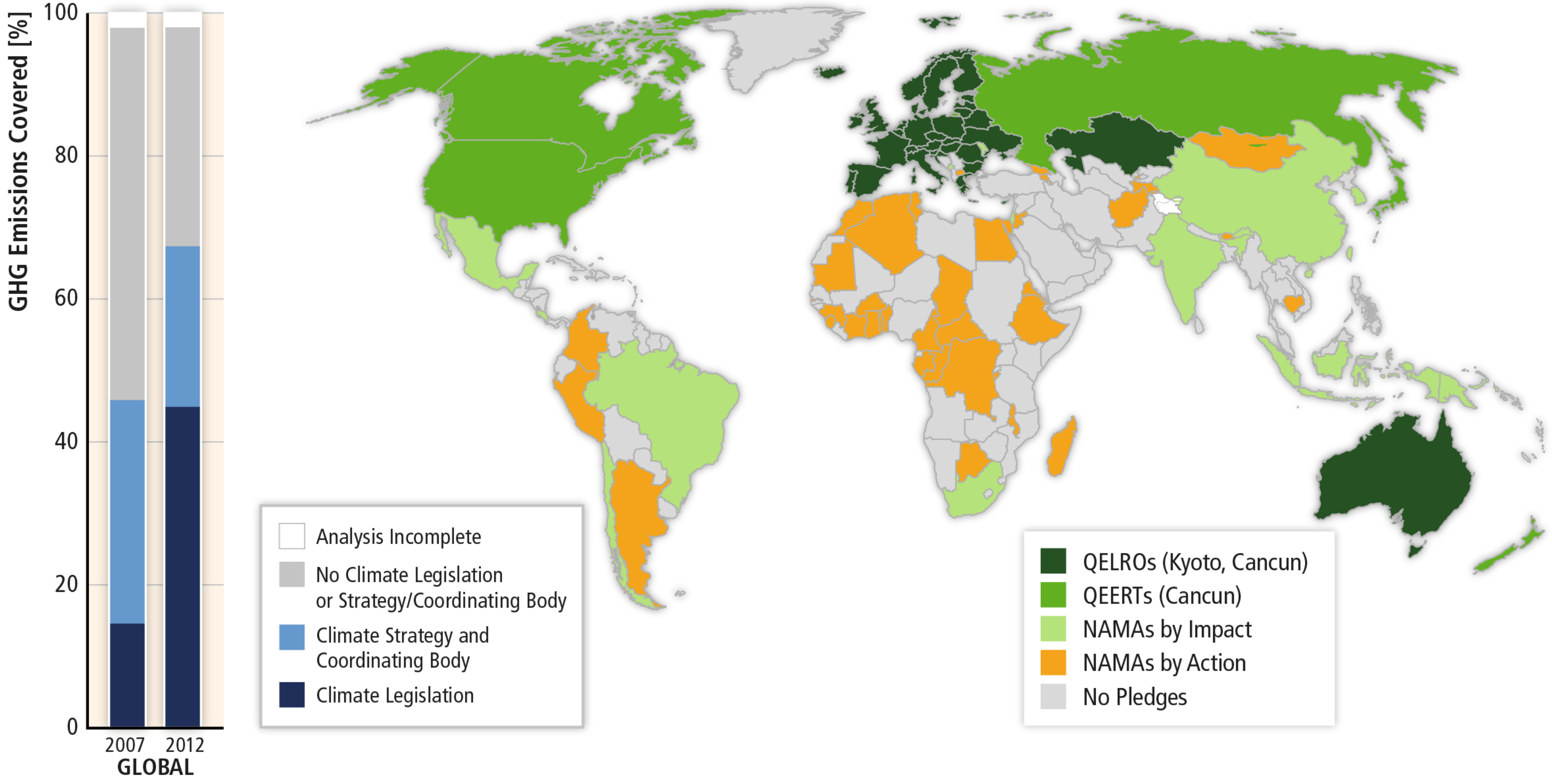
Behavioural change highlighted: younger people are using cars less



- higher fuel costs?
- better public transport?
- social networking?

Effective mitigation will not be achieved if individual agents advance their own interests independently.

There has been a considerable increase in national and sub-national mitigation policies since AR4.



Based on Figures 15.1 and 13.3

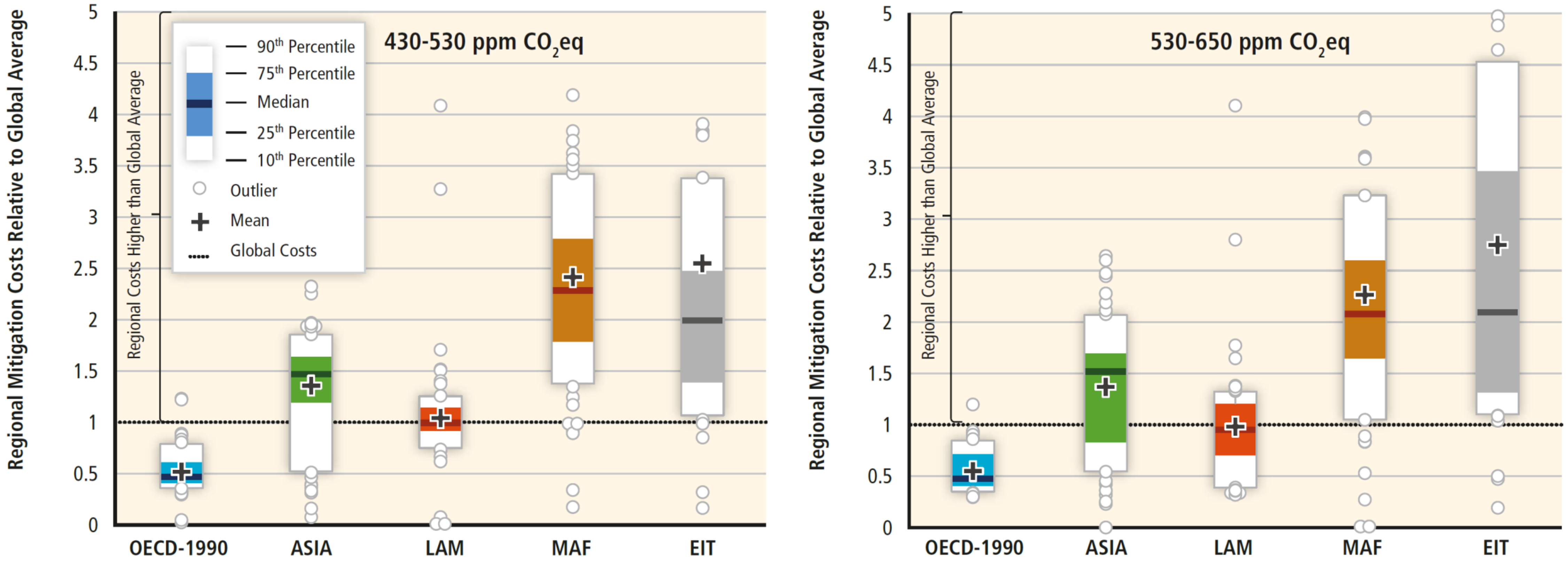
Agreements that involve many countries and deep emissions cuts are hard to achieve

The literature has shown that it is unlikely that large groups of countries commit to substantial emissions reductions

Large incentives to free-ride

Need to “bribe” reluctant players in the coalition

Regional carbon budgets and mitigation effort



	OECD-1990	ASIA	LAM	MAF	EIT
# of Scenarios (430-530 ppm CO_2eq)	105	101	88	99	79
# of Scenarios (530-650 ppm CO_2eq)	93	92	87	84	67

Final CEPL IPCC Meeting

April 22, from 4:30 pm to 6:00 pm

National and regional climate policy: roll-up to Paris 2015

Steven Rose, Senior Project Manager at the Electric Power Research Institute (EPRI) and IPCC Lead Author

Ken Mitchell, Special Assistant to the Director for EPA Region 4's Air, Pesticides, and Toxics Management Division and leader of the Region's Climate Change adaptation efforts

This presentation uses material from the presentation prepared by the Technical Support Unit of the Working Group III.

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